CLASS V INJECTION WELL MANAGEMENT PLAN FOR SINKHOLES FORT CAMPBELL, KENTUCKY

PURPOSE

To comply with State and Federal regulations in the management of Class V Injection Wells.

Figure 1 – Example of a sinkhole

OBJECTIVES

1) To protect human life and health.
2) To comply with Tennessee, Kentucky, and EPA regulations.
3) To protect drinking water resources quantity and quality and prevent degradation of these resources.
4) To protect and enhance drinking water quality at the level of designated use as designated by the states.
5) To prevent groundwater contamination

POLICY

APPLICATION FOR AUTHORIZATION TO OPERATE A CLASS V UNDERGROUND INJECTION WELL OR STORMWATER DISCHARGE TO THE SUB SURFACE:

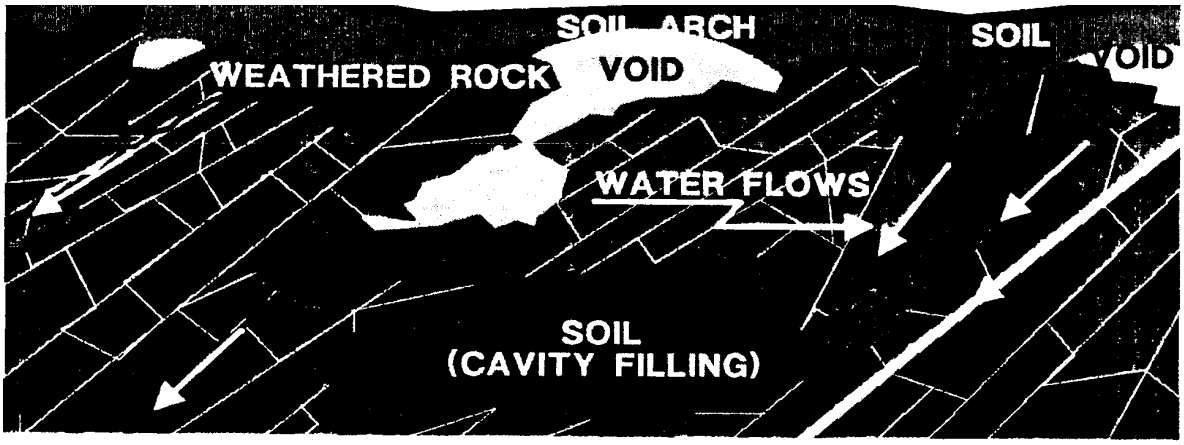
1) Fort Campbell, being almost completely underlain by limestone formations (karst geology), is highly susceptible to sinkhole formation, and must comply with regulations for Underground Injection Control (UIC) Class V Injection Wells. Class V Wells are regulated under the authority of the Safe Drinking Water Act (SDWA), USEPA Underground Injection Control Regulations, and State of Tennessee SDWA Rules. Fort Campbell is required by regulation to inventory and register all Class V Injection Wells. The Garrison Commander will be the signing authority for all registered Class V Injection Wells in both states and EPA Region 4. All injection wells have been inventoried and given an ID number that is recognized by the states of Tennessee and Kentucky and EPA Region 4.
2) The states of Tennessee and Kentucky and EPA Region 4 will provide a letter of authorization which allows Fort Campbell installation to discharge stormwater to selected Class V Injection Wells.

3) A location map of all inventoried Class V Injection Wells and their designated watershed areas is included in this management plan.

BACKGROUND

1) Sinkholes are a characteristic feature of karst terrain, which is prevalent in and around the area occupied by the Fort Campbell Military Reservation. The term "karst" describes a distinctive geology that indicates dissolution (also called chemical solution) of underlying soluble rocks by surface water or ground water (Figure 2). Although commonly associated with carbonate rocks (limestone and dolomite), other highly soluble rocks such as evaporates (gypsum and rock salt) can also be sculpted into karst terrain. Barren, rocky ground, caves, sinkholes, underground rivers, and the absence of surface streams and lakes usually characterize karst terrain. Conditions that promote karst development are well-jointed, dense limestone near the surface; a moderate to heavy rainfall; and good ground water circulation. Important stages in the formation of a sinkhole are shown in Figure 3. Figure 4 shows a schematic of a sinkhole.

Figure 2 – Cross-section of Karst Geology[1]

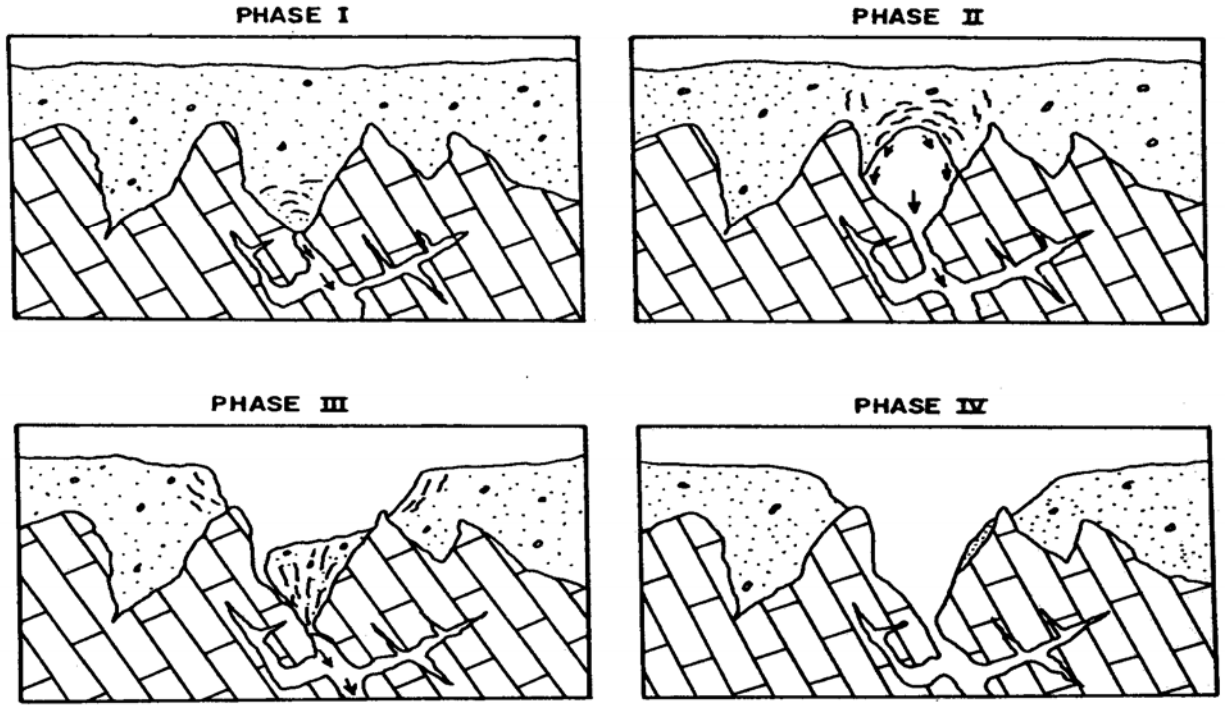


[1] From: Fischer, J.A. and J.J. Fischer. 1995. Remediation for Highways in Karst. Proceedings of the 46th Highway Geology Symposium, Charleston, West Virginia.

2) Karst, like landslides and coastal erosion, is a geologic hazard. Sudden collapse of an underground cavern or opening of a sinkhole can cause surface subsidence that can severely damage or destroy overlying structures such as a building, bridge, or highway. Improperly backfilled sinkholes are prone to both gradual and sudden subsidence and similarly threaten overlying structures. Sewage, animal wastes, and agricultural, industrial, and ice-control chemicals entering sinkholes as surface drainage are transferred directly and quickly into the ground water system, thereby posing a severe threat to potable water supplies.

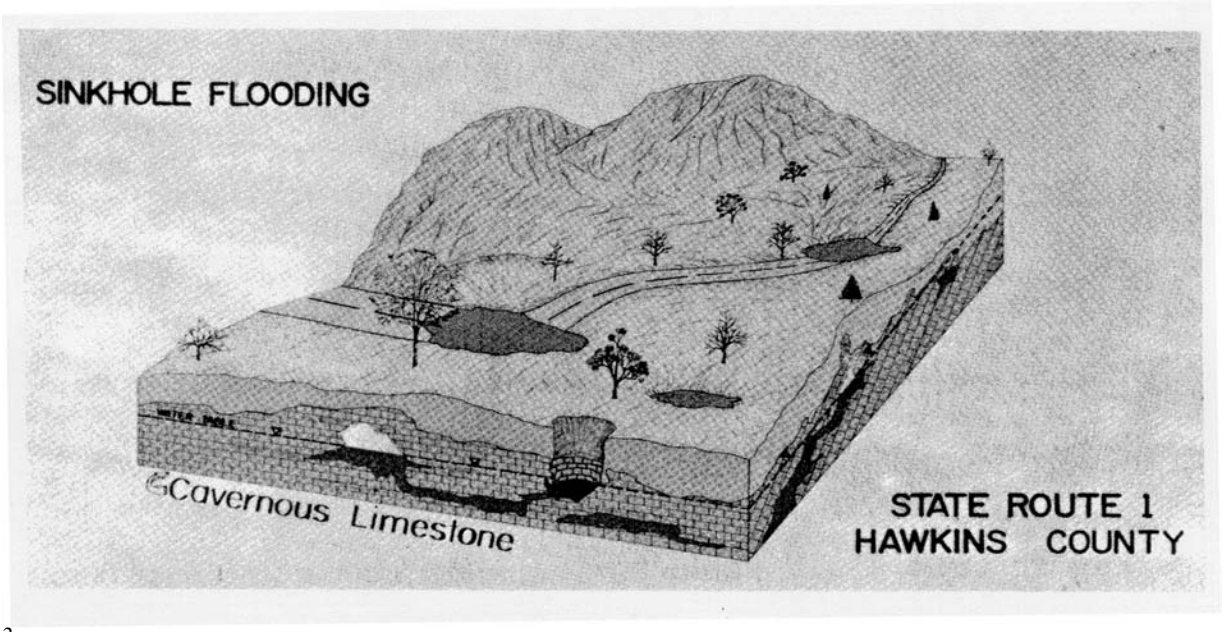
It must be emphasized that generally sinkholes are difficult to stabilize permanently, as they are chronic features that may grow or reform after filling. Moreover in the process of filling sinkholes, changes in the existing patterns of surface runoff and ground water flow must be avoided. A change in flow patterns may cause sinkhole growth.

Figure 3 – Stages of Sinkhole Formation[2]



[2]From: Moore, H.L. 1981. Karst Problems Along Tennessee Highways: An Overview. Proceedings of the 31st Highway Geology Symposium, Austin, Texas.

Figure 4 – Schematic of a Sinkhole[3]



[3]From: Moore, H.L. 1981. Karst Problems Along Tennessee Highways: An Overview. Proceedings of the 31st Highway Geology Symposium, Austin, Texas.

REQUIREMENTS

1) Class V UIC Management Plan

This Management Plan is considered a dynamic document. As new sinkholes are discovered, inventoried, and registered with Tennessee, Kentucky, and EPA Region 4 this Management Plan will be updated and posted on Fort Campbell's Environmental Division web site: http://www.campbell.army.mil/envdiv/en1.html.

2) Classification of Class V Injection Wells

Class V Injection Wells at Fort Campbell fall into six categories:

(a) Storm water runoff improved sinkhole – a sinkhole that has been modified or altered to promote or accept stormwater drainage. Figure 5 shows an example.
(b) Motor vehicle waste disposal wells – oil pits, which might have the potential to discharge to the subsurface.
(c) Large capacity septic systems – septic systems serving 20 or more persons per day and are designed to receive, treat, and dispose of solely sanitary wastes
(d) Agricultural drainage wells – structures consisting of either agricultural drain tiles or cisterns, which might have the potential to discharge to the subsurface.
(e) Large capacity cesspools – potential cesspools might have been located on Fort Campbell property. Seepage from them could potentially discharge to the subsurface.

Figure 5 – Storm Water Runoff Improved Sinkhole

3) Reporting New Sinkholes

a) When a sinkhole feature or a new collapsed sinkhole is discovered, it must be immediately reported to PWBC Environmental Division Compliance Branch (798-2877 or 798-9630). If a sinkhole feature is discovered during construction work or field clearing, all work near the sinkhole must stop until runoff controls are installed. PWBC will assign one or more specific individuals to inspect the structure and recommend appropriate short-and long-term action.
b) PWBC Environmental Division must be contacted within 24 hours (in case of construction project) of the discovery of the sinkhole. PWBC Environmental (on behalf of the GC) will give approval of the recommended course of action. Any designs/plans/costs will be the responsibility of the owner/proponent. Temporary diversion of runoff that would potentially impact waters entering the sinkhole, must be installed. Guidance for the closure or repair of collapsed sinkholes. PWBC Environmental Division will inventory and report to States or Region as required. All sediment and erosion control measures will be designed and installed as stated in the Fort Campbell Sediment and Erosion Control Management Plan.

4) Safety and Public Education

For safety reasons individuals reporting sinkholes should stay at a reasonably safe distance from collapsed areas. Sinkholes can be highly unstable and are subject to rapid movement and settling. A Public Education Program is being developed to educate the public on Class V Injection Wells/sinkholes. The education program will include Fort Campbell design guidance for planners and designers plus a public outreach education program for the general public, to include school age children, Fort Campbell population and Environmental Quality Officers.

5) Restricted Access

PWBC Roads and Grounds will make proper precautions to restrict access to the designated sinkhole area to the extent needed to protect the public.

6) Ground Disturbing Activities

In an area of ground disturbing activities such as construction, grading, sludge application, soil tilling, or vegetation clearing the following will apply:

a) Designers/Planners/Owners/Proponents will review the Fort Campbell Class V Injection Well Location Map and make a determination whether their project or activity impacts sinkhole drainage area. If a project or activity falls within the watershed area for that sinkhole water quantity and quality may be impacted. If a project or activity falls outside a designated sinkhole watershed the designer/planner/owner/proponent may proceed but must meet all requirements outlined in Fort Campbell's Stormwater Sediment and Erosion Control Management Plan. If a project falls within a designated sinkhole drainage area the following will be considered in the following order:
    i. Divert stormwater from the designated sinkhole watershed to surface waters or surface water stormwater system.
    ii. If diverted to surface water, plan and design project not to degrade water quality of existing stream or impact the existing storm water infrastructure. If diverting to surface flows is determined to be not feasible, approval must be given by PWBC Environmental Division. Class V Injection Wells are considered environmentally sensitive areas and it is in the long term best interests for Fort Campbell to divert stormwater runnoff away from Class V Injection Wells.

b) Project owners/proponents will be responsible for ensuring that all contractors/ parties are implementing all requirements in a timely and correct manner according to the Fort Campbell Stormwater Sediment and Erosion Control Management Plan.

TYPICAL SINKHOLE CLOSURE PROCEDURES

The Class V Injection Well Management Plan for Fort Campbell is designed to protect underground sources of drinking water. When implementation of BMPs or other control measures in a sinkhole drainage basin are unable to insure storm water quality meets standards to allow injection into or above the aquifer, the sinkhole must be closed. Also, when development occurs over a sinkhole, it must be closed.

The State of Tennessee Underground Injection Control Regulations allow the Department of Environment and Conservation to order that a Class V injection well be plugged and abandoned when the use of the system is determined to be a hazard to the ground water resource. Prior to abandonment, the regulations state that the well shall be plugged with cement in a manner approved by the Department and that the Department be notified when a Class V well is no longer useable. Chapter 1200-4-6.-14(11) of the regulations requires the owner of any Class V well to apply for a Plugging and Abandonment Permit to plug and abandon a Class V Injection Well.

As indicated in the Fort Campbell Technical Design Guide, Appendix A, when sinkholes are encountered they are to be closed if possible and storm water routed to natural storm drainage patterns. The Fort Campbell PWBC Environmental Division has adopted a policy to pursue closure of as many Class V injection wells within the developed area of the installation as practical.

When it has been determined that a sinkhole must be closed, a closure plan should be prepared by a geotechnical engineer and filed with the application for a Plugging and Abandonment Permit. The project owners/proponents are required to implement the following typical procedures for closing a Class V injection well:

1) Notify PWBC Environmental Division within 24 hours of the discovery of the sinkhole. PWBC will notify TDEC of the status of the well.
2) Install and maintain temporary diversion of runoff that could impact waters entering the sinkhole. Implement and maintain other BMPs identified by Environmental Division as soon as possible.
3) Conduct a site investigation by a qualified geotechnical engineer and prepare a closure plan. The schematic drawing attached illustrates typical sinkhole repair and closure.
4) File a Plugging and Abandonment Permit application with TDEC at least 7 days before any closure construction activity is anticipated.
5) Following are typical steps that may be anticipated with a closure plan. Since each sinkhole and drainage area are unique, the plans may be expected to vary as required by the unique conditions.

    a) Advise PWBC Environmental Division of beginning of closure.
    b) Clear vegetation within the anticipated area of excavation. Remove and stockpile topsoil.
    c) Excavate down to bedrock to remove loose soil and rock fragments. Remove all wet and soft soils that indicate presence of solution features or that yield under the weight of heavy construction equipment. The excavation may bottom out at 25-30 foot depth if

bedrock is not encountered. If unyielding overburden that does not indicate presence of solution activity is encountered at shallower depths, the excavation may terminate at this point if it is at or below future planned subgrade elevations.

d) Conduct the excavation in a manner that prevents soil plugging of the sinkhole throat.
e) After excavation is completed, the sinkhole must be inspected for features such as openings (throats) that directly or indirectly lead into the bedrock, condition of the bedrock surface along the bottom of the depression; and the depth, width, and shape of the sinkhole depression.
f) The interior of the sinkhole shall be lined with an appropriate area of a geotextile filter fabric.
g) “Shot rock” or boulder size limestone rock shall be used to cover and fill the openings in the bedrock or throat of the sinkhole. Clean concrete rubble may be also used. The rock shall be graded to minimize voids.
h) A sequentially smaller size of stone and gravel above the rock should be installed consisting of No. 2 stone, No. 57 stone, crusher run stone, and coarse sand. The thickness of the stone layers may vary from one to four feet depending on the sinkhole dimensions. A layer of geotextile fabric may be used in place of the crusher run stone.
i) During placement of No. 2 and No. 57 coarse stone, inject an approved cement-grout mix in the material to form an impermeable seal. Vibration shall be used to consolidate the seal and promote the infiltration of the grout into stone pores. The grouted zone should not penetrate below the water table.
j) A well-graded, modified stone mix or crusher-run stone shall be placed above the concrete fill. This stone should be installed in 1-ft lifts and compacted to provide a nearly impermeable layer.
k) Following the stone mix, install compacted lifts of well-graded soil to complete the repair. Each lift shall be benched into native soils at the perimeter of the excavation to prevent a plane of weakness. A 2-ft thick clay layer shall be used to form an impermeable cap about 1-2 ft below the planned ground surface.
l) Complete final fill to bring surface grade to at least 6 inches above the surrounding ground surface. Insure that the area has positive drainage and is free of standing water. Replace the stockpiled topsoil over the area and prepare seedbed.
m) Seed and mulch the completed repair to minimize soil loss due to erosion.
n) Advise PWBC of completion of closure
o) Inspect monthly for signs of collapse or settlement for the first three months after completion. Thereafter, inspect quarterly and after significant rainfall events. Repair settlement areas as needed to prevent formation of depressions with standing water

Figure 6 – Schematic Showing Generalized Approach to SInkhole Repair